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CLAIMS:

- 1. An ultrasonic waterjet apparatus comprising:
 - a) a generator module having:
 - i) an ultrasonic generator for generating and transmitting high-frequency electrical pulses;
 - ii) a control unit for controlling the
 ultrasonic generator;
 - iii) a high-pressure water inlet connected to a source of high-pressure water;
 - iv) a high-pressure water outlet connected to
 the high-pressure water inlet;
 - b) a high-pressure water hose connected to the high-pressure water outlet;
 - c) a gun connected to the high-pressure water hose, the gun having an ultrasonic nozzle having a transducer for receiving the high-frequency electrical pulses from the ultrasonic generator, the transducer converting the electrical pulses into vibrations that pulsate a waterjet flowing through the nozzle, creating a waterjet of pulsed slugs of water, each slug of water capable of imparting a waterhammer pressure on a target surface.
- 2. An ultrasonic waterjet apparatus as claimed in claim 1 wherein the transducer is a piezomagnetic transducer made of a magnetostrictive material.

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- 3. An ultrasonic waterjet apparatus as claimed in claim 2 wherein the magnetostrictive material is a Terfenol™ alloy.
- 4. An ultrasonic waterjet apparatus as claimed in claim 3 wherein the piezomagnetic transducer is a cylindrical core within a coil and a bias magnet.
- 5. An ultrasonic waterjet apparatus as claimed in claim 3 wherein the piezomagnetic transducer is a tubular core within a coil and a bias magnet.
- 6. An ultrasonic waterjet apparatus as claimed in claim 1 wherein the transducer is a piezoelectric transducer.
- 7. An ultrasonic waterjet apparatus as claimed in claim 1 further comprising a trigger for activating the ultrasonic generator to transform a continuous waterjet into a pulsed waterjet.
- 8. An ultrasonic waterjet apparatus as claimed in claim 7 wherein the trigger is located on the gun.
- 9. An ultrasonic waterjet apparatus as claimed in claim 8 wherein the gun is hand-held.
- 10. An ultrasonic waterjet apparatus as claimed in claim 1 wherein the generator module is mounted on wheels to be mobile.

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- 11. An ultrasonic waterjet apparatus as claimed in the generator module claim 1 wherein further comprises a water dump valve between the highpressure water inlet and the high-pressure water outlet and an actuator for opening and closing the water dump valve in response to signal transmitted from a dump valve trigger located on the gun.
- 12. An ultrasonic waterjet apparatus as claimed in claim 11 wherein the actuator is a solenoid.
- 13. An ultrasonic waterjet apparatus as claimed in claim 1 further comprising an ultrasonic signal cable for relaying the electrical pulses from the ultrasonic generator to the transducer.
- 14. An ultrasonic waterjet apparatus as claimed in claim 1 further comprising a compressed air hose for providing compressed air to cool the transducer.
- 15. An ultrasonic waterjet apparatus as claimed in claim 14 wherein the ultrasonic signal cable is housed within the compressed air hose.
- 16. An ultrasonic waterjet apparatus as claimed in claim 14 wherein the generator module further comprises a compressed air inlet and a compressed air outlet, the compressed air outlet being connected to the compressed air hose.

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- 17. An ultrasonic waterjet apparatus as claimed in claim 1 wherein the high-pressure water hose is sheathed in an abrasion-resistant nylon sleeve.
- 18. An ultrasonic waterjet apparatus as claimed in claim 1 wherein the ultrasonic nozzle has a single exit orifice.
- 19. An ultrasonic waterjet apparatus as claimed in claim 1 wherein the ultrasonic nozzle has a plurality of exit orifices.
- 20. An ultrasonic waterjet apparatus as claimed in claim 1 wherein the ultrasonic nozzle further comprises a rotating nozzle head.
- 21. An ultrasonic waterjet apparatus as claimed in claim 20 wherein the rotating nozzle head uses the water pressure in the nozzle to be self-rotating.
- 22. An ultrasonic waterjet apparatus as claimed in claim 21 wherein the ultrasonic nozzle further comprises a rotational damper to reduce the angular velocity of the rotating nozzle head.
 - 23. An ultrasonic waterjet apparatus as claimed in claim 22 wherein the ultrasonic nozzle further comprises a pair of outer jets in fluid communication with the waterjet to provide torque to self-rotate the rotating nozzle head.

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- 24. An ultrasonic waterjet apparatus as claimed in claim 23 comprising a single angled exit orifice.
- 25. An ultrasonic waterjet apparatus as claimed in claim 22 comprising a plurality of angled exit orifices.
- 26. An ultrasonic waterjet apparatus as claimed in claim 25 wherein the plurality of angled exit orifices generate torque to self-rotate the rotating nozzle head.
- 27. An ultrasonic waterjet apparatus as claimed in claim 1 wherein the transducer further comprises a microtip which acts as a velocity transformer by pulsing the waterjet.
- 28. An ultrasonic waterjet apparatus as claimed in claim 27 wherein the microtip is a stepped cylinder.
- 29. An ultrasonic waterjet apparatus as claimed in claim 28 wherein the microtip is made of a titanium alloy.
- 30. An ultrasonic waterjet apparatus as claimed in claim 27 wherein the microtip comprises a stub for connecting to the transducer, a stem for contacting and modulating the waterjet, and a flange between the stub and the stem, the flange defining a nodal

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plane at which the amplitude of standing waves set up at the microtip is zero.

- 31. An ultrasonic waterjet apparatus as claimed in claim 30 wherein the microtip further comprises an O-ring seal at the nodal plane for isolating the transducer from the waterjet.
- 32. An ultrasonic waterjet apparatus as claimed in claim 31 wherein the O-ring have a hardness rating of at least 85 durometer.
- 33. An ultrasonic nozzle for use in an ultrasonic waterjet apparatus, the ultrasonic nozzle comprising a transducer for converting highfrequency electrical pulses into mechanical vibrations that pulsate a waterjet flowing through the nozzle, creating a waterjet of pulsed slugs of water, each slug of water capable of imparting a waterhammer pressure on a target surface, the transducer comprising a microtip with a seal for isolating the transducer from the waterjet, seal being located at a nodal plane where the amplitude of standing waves set up along the microtip is zero.
- 34. An ultrasonic nozzle as claimed in claim 33 wherein the microtip is a stepped cylinder.
- 35. An ultrasonic nozzle as claimed in claim 34 wherein the microtip is made of a titanium alloy.

- 36. An ultrasonic nozzle for use in an ultrasonic apparatus, the ultrasonic waterjet nozzle comprising a transducer for converting highfrequency electrical pulses into mechanical vibrations that pulsate a waterjet flowing through the nozzle, creating a waterjet of pulsed slugs of water, each slug of water capable of imparting a waterhammer pressure on a target surface, the nozzle comprising a rotating nozzle head.
- 37. An ultrasonic nozzle as claimed in claim 36 wherein the rotating nozzle head is self-rotating by the torque generated by deflecting the waterjet.
- 38. An ultrasonic nozzle as claimed in claim 37 wherein the rotating nozzle head has two outer jets.
- 39. An ultrasonic nozzle as claimed in claim 37 wherein the rotating nozzle head further comprises a damper to limit the angular velocity of the rotating nozzle head.
- 40. A method of cutting with an ultrasonically pulsed waterjet, the method comprising the steps of:
 - a) forcing a high-pressure continuous-flow waterjet through a nozzle;
 - b) generating high-frequency electrical pulses;
 - c) transmitting the high-frequency electrical pulses to a transducer;

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- d) transducing the high-frequency electrical pulses into mechanical vibrations;
- e) pulsating the high-pressure continuous flow waterjet to transform it into a pulsated waterjet of discrete water slugs, each water slug capable of imparting a waterhammer pressure on a target surface; and
- f) directing the pulsated waterjet onto a material to be cut.
- 41. A method of cleaning with an ultrasonically pulsed waterjet, the method comprising the steps of:
 - a) forcing a high-pressure continuous-flow waterjet through a nozzle;
 - b) generating high-frequency electrical pulses;
 - c) transmitting the high-frequency electrical pulses to a transducer;
 - d) transducing the high-frequency electrical pulses into mechanical vibrations;
 - e) pulsating the high-pressure continuous flow waterjet to transform it into a pulsated waterjet of discrete water slugs, each water slug capable of imparting a waterhammer pressure on a target surface; and
 - f) directing the pulsated waterjet onto a material to be cleaned.
- 42. A method of cleaning as claimed in claim 41 further comprising the step of self-rotating a rotating

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nozzle head so that the pulsated waterjet strikes a larger surface area.

- 43. A method cleaning as claimed in claim 41 further comprising the step of splitting the pulsated waterjet into a plurality of sub-waterjets so that the sub-waterjets strike a larger surface area.
- 44. A method of deburring with an ultrasonically pulsed waterjet, the method comprising the steps of:
 - a) forcing a high-pressure continuous-flow waterjet through a nozzle;
 - b) generating high-frequency electrical pulses;
 - c) transmitting the high-frequency electrical pulses to a transducer;
 - d) transducing the high-frequency electrical pulses into mechanical vibrations;
 - e) pulsating the high-pressure continuous flow waterjet to transform it into a pulsated waterjet of discrete water slugs, each water slug capable of imparting a waterhammer pressure on a target surface; and
 - f) directing the pulsated waterjet onto a material to be deburred.
- 45. A method of removing surface coatings with an ultrasonically pulsed waterjet, the method comprising the steps of:

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- a) forcing a high-pressure continuous-flow waterjet through a nozzle;
- b) generating high-frequency electrical pulses;
- c) transmitting the high-frequency electrical pulses to a transducer;
- d) transducing the high-frequency electrical pulses into mechanical vibrations;
- e) pulsating the high-pressure continuous flow waterjet to transform it into a pulsated waterjet of discrete water slugs, each water slug capable of imparting a waterhammer pressure on a target surface; and
- f) directing the pulsated waterjet onto the surface coating to remove the coating from the surface.
- 46. A method of cleaning as claimed in claim 45 further comprising the step of self-rotating a rotating nozzle head so that the pulsated waterjet strikes a larger surface area.
- 47. A method cleaning as claimed in claim 45 further comprising the step of splitting the pulsated waterjet into a plurality of sub-waterjets so that the sub-waterjets strike a larger surface area.
- 48. A method of breaking rock-like materials with an ultrasonically pulsed waterjet, the method comprising the steps of:

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- a) forcing a high-pressure continuous-flow
 waterjet through a nozzle;
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- b) generating high-frequency electrical pulses;
- c) transmitting the high-frequency electrical pulses to a transducer;
- d) transducing the high-frequency electrical pulses into mechanical vibrations;
- e) pulsating the high-pressure continuous flow waterjet to transform it into a pulsated waterjet of discrete water slugs, each water slug capable of imparting a waterhammer pressure on a target surface; and
- f) directing the pulsated waterjet onto the rocklike material to be broken.